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CULTURAL EVOLUTION AND PALEOGEOGRAPHY ON THE SANTA BARBARA COAST: A 9600-YEAR ^{14}C RECORD FROM SOUTHERN CALIFORNIA*

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INTRODUCTION

Since 1984, a large multi-disciplinary archaeological team, under the direction of the author, has collected artifactual, ecofactual, and radiocarbon samples from a series of Native American sites spanning the past 9600 ^{14}C years. Occupied historically by the Chumash Indians, the Santa Barbara coast (Fig 1) has seen dramatic cultural and environmental change during the course of the Holocene. One of the goals of the research is to reconstruct patterns in the evolution of the local coastline, while examining the effects of environmental change on human adaptation along the Santa Barbara coast.

All ^{14}C samples were analyzed by Beta Analytic, Inc of Coral Gables, Florida, under the direction of Murry Tamers and Jerry Stipp. Unless otherwise noted, all samples consisted of marine shell. Prior to submittal, samples were carefully washed to remove adhering sediment, rootlets, or other macroscopic contaminants. In the laboratory, marine shell samples were pretreated in a dilute acid bath to remove surface layers susceptible to exchange with external radiocarbon reservoirs. The remaining shell was then converted to carbon dioxide which was used for benzene synthesis. Charcoal samples were carefully sorted in the lab to remove any macroscopic rootlets or other extraneous objects and then submitted to a series of acid and alkali washes to remove carbonates and organic acids. Counting of ^{14}C activity was conducted with a liquid scintillation spectrometer.

Small (<1g) shell samples were analyzed using the Accelerator Mass Spectrometry (AMS) method. AMS samples were analyzed by Beta Analytic, Inc staff in Zurich. According to Tamers (pers commun, 1986), the AMS samples

> were pretreated by etching away the outer layers with controlled heating. They were then reacted with magnesium in a special copper arrangement to form elemental carbon. After cleaning, this was mixed with silver powder and applied to copper targets. The AMS measurements were made in triplicate.]. . . Carbon 13 is measured in the accelerator beam. This is done concurrently with the carbon 12 and carbon 14 measurements, using fast pulsing techniques. Carbon 13 values are used to adjust for isotope effects generated in both nature and in the laboratory chemical and physical processing. We measure this for each AMS sample and final dates are appropriately corrected. Since the carbon 13 observed is a combination of natural and artificial effects, it cannot be used for geochemical interpretations. For that reason, C13 values are not given. . . .

According to Tamers and Stipp (pers commun, 1987), all dates presented below are

* *Editors' note:* It is always useful to publish an annotated list of dates with a theme. We would like to encourage this sort of publication for the future.

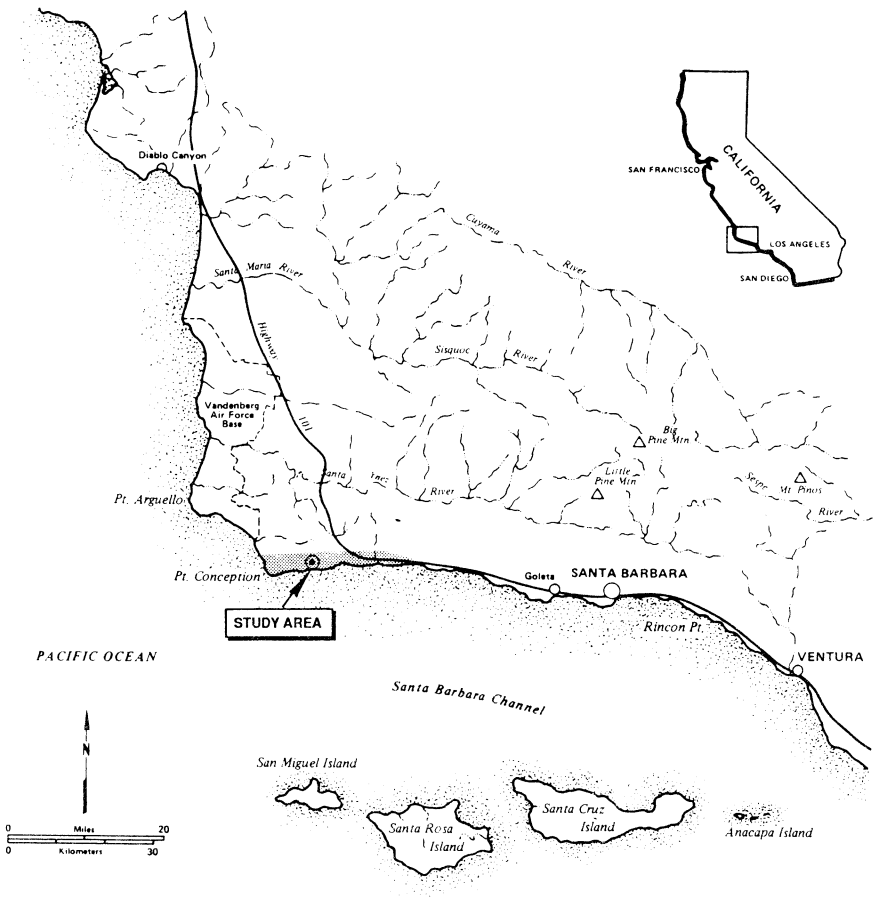

Fig. 1. Location of the study area

reported as RCYBP (radiocarbon years before 1950 AD). By international convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international conventional, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted. . . . Stable carbon ratios are . . . calculated relative to the PDB-1 international standard; the adjusted ages are normalized to −25 per mil carbon 13.

In the following pages, 47 ^{14}C dates from 14 separate archaeological sites are discussed. The sites are presented from oldest to youngest, and organized by Early Holocene (6650–10,000 yr BP), Middle Holocene (3350–6650 yr BP), and Late Holocene (0-3350 yr BP). Eighteen of the dates have been corrected for isotopic fractionation, including 16 dates listed in

TABLE 1
Isotopic fractionation adjustments for marine shell and charcoal ^{14}C determinations

Beta #	Shell taxa	^{14}C age BP	$^{13}C/^{12}C$	Adjusted ^{14}C age	$^{13}C/^{12}C$ correction
12949	Estuarine shell	7840 ± 110	−0.85‰	8235 ± 115	+395 yr
13596	*Mytilus californianus*	3300 ± 70	+0.75‰	3730 ± 70	+430 yr
15046	*Protothaca staminea*	300 ± 80	+1.59‰	740 ± 80	+440 yr
15047	*Protothaca staminea*	470 ± 80	+1.40‰	910 ± 80	+440 yr
15048	*Protothaca staminea*	640 ± 60	+1.03‰	1060 ± 60	+420 yr
15049	*Protothaca staminea*	430 ± 80	+1.45‰	870 ± 80	+440 yr
15050	*Protothaca staminea*	Modern	+1.22‰	430 ± 60	+430 yr
17210	*Tivela stultorum*	670 ± 70	+2.08‰	1120 ± 70	+450 yr
17211	*Haliotis rufescens*	400 ± 80	+1.87‰	840 ± 80	+440 yr
17212	*Haliotis rufescens*	260 ± 80	+2.57‰	710 ± 80	+450 yr
17213	*Haliotis rufescens*	310 ± 90	+2.18‰	760 ± 90	+450 yr
18532	*Mytilus californianus*	1320 ± 70	+1.25‰	1750 ± 70	+430 yr
18534	*Polonices lewisii*	5930 ± 100	+0.10‰	6340 ± 100	+410 yr
18608	Charred wood	4280 ± 80	−24.00‰	4300 ± 80	+20 yr
20405	*Mytilus californianus*	6810 ± 150	+0.27‰	7230 ± 150	+420 yr
20406	*Mytilus californianus*	6660 ± 100	+0.97‰	7090 ± 100	+430 yr
Mean marine shell adjustment (n = 15)					+432 yr

Table 1. To avoid confusion in the correlation of corrected and uncorrected dates, however, the ^{14}C ages presented in the date list *do not include adjustments for isotopic fractionation,* except for AMS dates where the isotope effects of natural and laboratory processes could not be separated. For those marine shell dates that have not been adjusted for isotopic fractionation, the result of 15 $^{13}C/^{12}C$ analyses indicates that an average correction of +430 yr should be applied prior to further corrections for the reservoir or DeVries effects (Table 1).

ACKNOWLEDGMENTS

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ARCHAEOLOGIC SAMPLES

United States

California

BAI Beta-20411. CA-SBA-2088 **9600 ± 160**

Fragment of *Saxidomus nuttalli* (Washington clam), 20g, coll during mechanical excavation at ephemeral archaeol site, 1km W of Canada de la Gaviota (34° 28′ 15″ N, 120° 14′ 00″ W) and 300m N of Pacific Ocean, on uplifted marine terrace ca +75m asl. Coll autumn 1986 by A Cruz. *Comment:* spatial context of sample is poor, but adhering sediment indicates that shell valve originated in soil matrix of site. Considering the context, lack of corroborating dates, and the fact that ^{14}C age is one of earliest from the California coast, date should be suspect. However, corroborating evidence includes 1) other early Holocene sites also contain shellfish assemblages dominated by *Saxidomus;* 2) no non-cultural mechanism is known which could transport early Holocene-age shell to site location; 3) discovery of a fluted point elsewhere in project area suggests Paleo-Indian occupation of area (Erlandson, Cooley & Carrico, 1987); and 4) several other sites from south-central California coast have been dated to 9000 yr BP or older.

CA-SBA-1807, Early Holocene series

Marine shells from two discrete loci in large residential village W of Alegria Canyon, on Hollister Ranch (34° 28″ N, 120° 16′ 30″ W). Site is on uplifted marine terrace, elev 38m, and contains artifacts characteristic of Phase Ex, Early period (King, 1981), Oak Grove culture (Rogers, 1929), or Millingstone horizon (Wallace, 1955).

BAI Beta-10228. 20–30cm **7720 ± 90**

Mixed shell fragments, 41g, from WESTEC Unit 2. Coll 1984 by WESTEC. *Comment:* date provides average age of shell fragments, suggesting early Holocene occupation of site.

BAI Beta-10736. Surface **6340 ± 80**

Fragments of single *Polonices lewisii* (Moon snail) shell coll from site surface midway between central midden area and discrete non-midden artifact scatter to SE. Coll 1984 by J Erlandson and F Duncan, UCSB. *Comment:* date should represent age of prehistoric shell colln. Other dates from site, however, suggest that Beta-10736 is anomalous or that site has had multiple occupations.

BAI Beta-12347. 30–40cm **7830 ± 70**

Tivela stultorum (Pismo clam), 48g, from WESTEC Unit 2, 10cm below Beta-10228. Coll 1984 by WESTEC. *Comment:* date supports early Holocene age for occupation of central midden area.

BAI Beta-12949. Unit 12, 80–100cm **7840 ± 110**

Mixed marine shell fragments, 36g, from central midden area. Coll May 1985 by J Moore. *Comment:* ^{14}C date provides average age for shell

fragments. Very little shell was recovered from upper 60cm of Unit 12, so this date represents age of upper portion of midden.

BAI Beta-12950. Unit 12, 100–120cm **7770 ± 100**

Saxidomus nuttalli fragments, 35g. Coll May 1985 by J Moore. *Comment:* date corroborates other early Holocene ^{14}C determinations from central midden area.

BAI Beta-12951. Unit 12, 120–140cm **8000 ± 110**

Saxidomus nuttalli fragments, 35g. Coll May 1985 by J Moore. *Comment:* application of Stuiver, Pearson, and Braziunas (1986, p 1013) correction for marine samples suggests early site occupation, ca 8600 cal BP.

BAI Beta-16171. Unit 10, 40–60cm **8600 ± 125**

Fragment of *Chione* sp, 0.6g, from SE locus of site, non-midden area dominated by milling artifacts, hammerstones, and core tools. Coll May 1985 by J Moore. *Comment:* shell fragment analyzed by AMS. Sample subm to test contemporaneity of SE locus and central midden area. Since date includes ^{13}C correction of ca +430 yr, contemporaneity appears to be confirmed.

BAI Beta-16172. Unit 17, 0–20cm **40,500 ± 1200**

Fragment of unidentified shell, 0.5g, from SE locus of site. Coll June 1985 by J Moore. *Comment:* shell fragment analyzed by AMS. Pleistocene age suggests that shell is fossil in origin, derived from uplifted Last Interglacial beach deposits located upslope and below cultural stratum. Date should be regarded as min.

General Comment: shellfish remains from CA-SBA-1807 indicate that a productive estuary was located near site during early Holocene, formed by rising postglacial sea level (Erlandson, 1985). Lower sea levels, ca −20m, should have exposed broader coastal plain, resulting in increased terrestrial productivity. These features sharply contrast with modern geography around site, where productive estuarine shellfish habitats are virtually nonexistent and very narrow coastal plain restricts terrestrial productivity.

Artifacts recovered from CA-SBA-1807 suggest that occupants relied on relatively unsophisticated technology dominated by manos and metates, as well as large battered core tools probably used in manufacture and maintenance of milling equipment. Projectile points are extremely rare at site, suggesting that hunting was relatively unimportant during this period.

Faunal assemblage indicates that shellfish were dominant animal resource, with supplemental protein provided by fish, land mammals, and sea mammals. Evidence suggests that mixed economy based largely on littoral foraging (for protein) and terrestrial plant collecting (for calories) existed on southern California coast by at least 8500 cal BP.

CA-SBA-2061, Early Holocene series

Marine shells from small Early period shell midden 200m from ocean at 50m elev. Midden is on uplifted marine terrace 1.3km W of Canada de la

Gaviota (34° 28′ 15″ N, 120° 14′ 30″ W) next to small intermittent drainage. Excavation uncovered small lithic assemblage (flake and core tools, chipped stone debitage, milling stones, etc) and faunal assemblage dominated by estuarine shell, with small amounts of fish, terrestrial mammal, and sea mammal bone.

BAI Beta-18533. Surface **7610 ± 110**

Fragment of *Saxidomus nuttalli,* 58.5g, from grading spoils derived from surficial soil. Coll Oct 1986 by J Erlandson. *Comment:* date confirms expected early Holocene age for site, based on similarity of molluscan spp to CA-SBA-1807 and CA-SBA-2057 shellfish assemblages.

BAI Beta-21000. Surface **7590 ± 110**

Fragment of *Saxidomus nuttalli,* 31.8g, recovered from grading spoils from surficial soil. Coll Oct 1986 by J Erlandson. *Comment:* date is consistent with earlier sample subm from site.

BAI Beta-21001. Unit 6, 20–40cm **7300 ± 110**

Chione fragments, 28.5g, recovered from upper portion of midden exposed in test unit excavated through undisturbed soils just south of graded right-of-way. Coll Dec 1986 by T Hannahs and J Schmidt. *Comment:* since sample consists of multiple shell fragments, date should represent average age for later occupation of site. Sample subm to test hypothesis that CA-SBA-2061 is single-component site, with all archaeologic remains derived from early Holocene occupation.

BAI Beta-21002. Unit 6, 80–100cm **7380 ± 110**

Chione fragments, 27.5g, recovered near base of midden deposit. Coll Dec 1986 by T Hannahs and J Schmidt. *Comment:* date confirms contemporaneity of midden refuse at CA-SBA-2061, suggesting that site was occupied over several hundred years between ca 7800 and 8200 cal BP.

General Comment: although smaller, artifact and ecofact assemblage recovered from CA-SBA-2061 is similar to the CA-SBA-1807, CA-SBA-2057, and CA-SBA-96 assemblages, which are roughly contemporary. Similarity suggests that cultural ecologic and paleoenvironmental reconstruction for CA-SBA-1807 is characteristic of broader patterns of coastal paleogeography and human adaptation in area.

BAI Beta-17753. CA-SBA-2057, −3.9m **7550 ± 100**

Saxidomus nuttalli fragment, 22g, from buried Early period shell midden at base of Canada de la Agua Caliente, 22m elev, 800m N of Pacific Ocean on Hollister Ranch (34° 28′ 30″ N, 120° 15′ W). Small midden is exposed in bank of perennial stream, below up to 4m of alluvium. Midden is 5 to 20cm thick and lies in weakly developed anthropogenic soil formed in gravelly alluvium. Coll Aug 1986 by J Erlandson. *Comment:* date is consistent with earlier dates of 8040 ± 95 (UM-1464) and 7500 BP obtained by USGS (G Kennedy, pers commun, 1986; Yerkes *et al,* 1981). Midden contains abundant estuarine shell, with small amounts of fish and terrestrial

mammal bone, charcoal, and rare chipped and groundstone artifacts. Soil context, small site size, and limited artifact diversity all suggest CA-SBA-2057 was occupied for only a short period ca 8100 cal BP.

CA-SBA-96, Early-Middle Holocene series

Marine shells from midden on E rim of Canada de la Gaviota (34° 28′ 30″ N, 120° 13′ 30″ W) ca 300m N of sea cliff and +30m asl. CA-SBA-96 was first described by D B Rogers (1929) as Oak Grove site, investigated by D Lathrap (UCB) and N Gabel (UCSB) in 1951.

BAI Beta-21556. Unit 25W, 80–100cm **7520 ± 120**

Chione undatella valve, 19.4g, from lower half of shell lens exposed 60–100cm below surface in bank of Hwy 101. Coll May 1987 by J Erlandson. *Comment:* date is consistent with age of nearby sites (CA-SBA-1807, -2061, and -2057) that contain abundant estuarine shell and milling equipment. ^{14}C date confirms Rogers (1929) hypothesized Oak Grove assoc.

BAI Beta-22075. Unit 10W, 20–40cm **7590 ± 150**

Chione californiensis valve, 19.7g, from same shell lens as Beta-21556. Coll May 1987 by J Erlandson. *Comment:* date is consistent with Beta-21556, confirming early Holocene age of buried shell lens from which recent samples were removed.

BAI Beta-15931. Unit D6, 60–75cm **5940 ± 80**

Fragment of *Polonices lewisii*, 50g. Coll 1951 by D Lathrap and N Gabel. *Comment:* date suggests continuous or intermittent site occupation for over 1500 years of Early period. Beta-21556 and -22075 may be more reliable indicators of site age, however, since sample treatment during 35 years of storage is unknown and *Polonices* sample from CA-SBA-1807 (Beta-10736) also appears anomalous.

General Comment: current evidence suggests that early Holocene occupation (ca 8100–8200 cal BP) of CA-SBA-96 is most likely, although occupation during middle Holocene is also possible. CA-SBA-96 shell assemblage is dominated by estuarine spp, although rock-perching mussels are also present.

CA-SBA-1666, Early Holocene series

Marine shell samples from very large (150 × 250m) and dense shell midden 4.3km N of Point Conception (34° 29′ N, 120° 29′ W), major biogeographic boundary on California coast. CA-SBA-1666 is on uplifted marine terrace, 60m elev, adjacent to spring that feeds small unnamed drainage on Bixby Ranch.

BAI Beta-20406. Unit 1, 20–40cm **6660 ± 100**

Fragment of *Mytilus californianus* (California mussel), 24g, from upper portion of midden. Coll Feb 1987 by L Santoro, WESTEC. *Comment:* date suggests occupation of this portion of site during Phase Ex of King's (1981) Early period.

BAI Beta-20405. Unit 1, 60–80cm **6810 ± 150**

Fragment of *Mytilus californianus,* 19g, from lower portion of midden. Coll Feb 1987 by L Santoro and J Erlandson. *Comment:* date is consistent with Beta-20406.

General Comment: preliminary analysis suggests that shellfish also dominated meat diet at site, consistent with pattern observed at other early Holocene Millingstone sites. However, shellfish assemblage consists largely of mussels and other rocky shore spp, similar to other early sites in Vandenberg area which bounds study area on N (Glassow, 1981). Available archaeologic data suggest that productive estuaries did not form along unprotected Vandenberg coast during Holocene.

Canada de la Gaviota, Middle Holocene series

Charcoal and marine shells from two sites in Canada de la Gaviota area, ca 40km W of Santa Barbara. Perennial Gaviota Creek is only stream in study area that cuts through 1000m high Santa Ynez Mts. Thus, creek has considerably larger catchment than other drainages in area.

BAI Beta-18534. CA-SBA-97, Unit 15S/OW 100–120cm **5930 ± 100**

Heavily weathered fragment of *Polonices lewisii,* 20g, recovered near base of archaeologic deposit in N site area, on W rim of Canada de la Gaviota (34° 28′ 15″ N, 120° 13′ 30″ W) 175m N of sea cliff and ca +35m asl. Coll Oct 1986 by T Cooley. *Comment:* CA-SBA-97 has been attributed to historic Chumash village of *Nomgio.* This date, derived from area outside main shell midden, but containing abundant chipped stone and bone assemblage, suggests that site had multiple occupations. Recovery of several large dart points supports Early period occupation of tested area.

BAI Beta-18608. CA-SBA-2067 Feature 1 **4300 ± 80**

Large chunk of wood charcoal, ca 20g, underlying Feature 1, large (2m × 1.5m) cluster of burned sandstone cobbles and boulders ca 1km N of ocean on floor of Canada de la Gaviota (34° 29′ 00″ N, 120° 13′ 30″ W). Coll Nov 1986 by J Erlandson. *Comment:* Feature 1 appears to represent roasting pit or oven, possibly for cooking agave (*Yucca whipplei*), which is abundant on slopes adjacent to site. Several similar rock features were observed in same area. Artifacts and faunal remains assoc with Feature 1 are sparse, but include small amounts of chipping debris, shell (some burned), and scattered charcoal.

BAI Beta-20410. CA-SBA-2067, Stratum A-2 **3820 ± 100**

Septifer bifurcatus (Platform mussel) shells, 23g, from midden lens exposed 260cm below surface in wall of pipeline trench immediately E of Gaviota Creek channel. Coll Dec 1986 by J Erlandson. *Comment:* midden lens, 20cm thick, consisting predominantly of these tiny mussel shells, was probably once coterminous with Feature 1 stratum.

General Comment: shell remains from CA-SBA-2067 indicate that rocky shore habitats provided bulk of shellfish consumed during middle Holo-

cene occupation. This suggests that estuarine habitats, if present in Gaviota Canyon ca 4000 BP, were not productive. Burial of lower midden suggests that flood plains near mouths of coastal canyons continued to be unstable landforms, suitable only for temporary human settlement.

CA-SBA-1808, Late Holocene series

Four marine shell samples recovered from midden area on N edge of site that appears to span transition between King's (1981) Early and Middle periods. CA-SBA-1808 is on canyon rim E of perennial Agua Caliente Creek (34° 28′ 00″ N, 120° 15′ 00″ W), ca 2km W of Gaviota State Beach. Tested midden area lies 200m N of sea cliff and 45m asl on uplifted marine terrace dating to Last Interglacial.

BAI Beta-13594. Unit 8, 20–40cm **3310 ± 90**

Mytilus californianus fragments, 32g, from upper portion of midden. Coll 1985 by J Rudolph, UCSB. *Comment:* Stuiver, Pearson and Braziunas (1986, p 1002) correction suggests calendar age of 3400 cal BP. Date correlates with Phase 1 of King's (1981) Middle period.

BAI Beta-13595. Unit 8, 60–80cm **3100 ± 70**

Mytilus californianus fragments, 50g, from intermediate level of midden. Coll April 1985 by J Rudolph. *Comment:* Beta-13595 and -13594 appear to be stratigraphically reversed, but overlap at 96% confidence level (2 sigma).

BAI Beta-13956. Unit 8, 100–120cm **3300 ± 70**

Mytilus californianus fragments, 50g, from lower portion of shell midden. Coll April 1985 by J Rudolph. *Comment:* three dates from Unit 8 consistently indicate occupation of N midden area at CA-SBA-1808 occurred ca 3100 to 3500 cal BP.

BAI Beta-10735. STP, 0–90cm **3870 ± 90**

Numerous small shell fragments (mixed spp) from Shovel Test Pit (STP) excavated in single level through upper 90cm of midden deposit. Coll 1984 by R Peterson, UCSB. *Comment:* some shell from STP appeared abraded or beach rolled, probably introduced into midden incidentally with mussels, primary food species at site. Although effort was made to remove abraded shell fragments prior to subm, incorporation of small number of fragments from older geologic contexts may have skewed this date. Beta-13594, -13595, and -13596 are considered more accurate estimates of site chronology.

General Comment: >85% of shell assemblage recovered in Unit 7 at CA-SBA-1808 consisted of species that inhabit rocky substrates, indicating that rocky shore habitats dominated intertidal area around site ca 3000 to 3500 cal BP.

CA-SBA-2028, Late Holocene series

Charcoal and shell samples from buried archaeologic site on flood plain of Canada del Cementerio, 1.6km E of Gaviota Canyon (34° 28′ 30″

N, 120° 12′ 30″ W), ca 250 N of Pacific and +10m asl. Site buried in paleosol formed in alluvial canyon fill and sealed beneath discontinuous cobble lens. Prehistoric component contains abundant chipped stone artifacts, charcoal, and burned bone. Surface soil contains historic debris from short-lived industrial community ("Alcatraz") dating between AD 1900 and 1930.

BAI Beta-21073. Unit 30S/35E, 180–200cm **3050 ± 120**

Small burned shell (*Mytilus californianus*) fragment, 0.1g, from sealed context in A-2 soil beneath cobble sheet. Coll 1985 by T Cooley. *Comment:* AMS date (ETH-3014) includes correction (ca +430 yr) for isotopic fractionation. Date is consistent with age estimates based on intensity of pedogenesis in A-1 and A-2 soils and suggests site occupation during Middle period (King, 1981) of Santa Barbara Channel prehistory.

BAI Beta-21072. Unit 30S/35E, 180–200cm **2750 ± 120**

Numerous fragments of wood charcoal, 2.8g, scattered through A-2 soil. Coll 1985 by T Cooley. *Comment:* after pretreatment, only 0.6g of carbon remained; analysis included double normal counting time to reduce statistical error. Average age for scattered charcoal fragments is similar to marine shell date.

General Comment: since effect of isotopic fractionation generally adds 400–450 yr to Santa Barbara coast shell dates, these two determinations are internally consistent. Age of CA-SBA-2028 suggests that periodic flooding of canyon bottoms continued during Late Holocene. Lack of abundant marine shell at site precludes paleogeographic reconstruction of adjacent coastline.

CA-SBA-1881, Agua Caliente Late Holocene series

Marine shell and wood samples from selected strata in series of 14 buried midden layers at mouth of Canada de la Agua Caliente (34° 28′ 00″ N, 120° 15′ 00″ W), ca 2km W of Gaviota State Beach and 50m N of ocean. Buried midden layers consist of numerous weakly developed soils, 5 to 20cm thick, formed in sequence of overbank alluvial strata deposited on E side of Agua Caliente Creek. Periodic channel cutting has removed or truncated these layers on W side of canyon.

BAI Beta-18532. Stratum A-1[4], −175cm **1320 ± 70**

Mytilus californianus shell valves, 31g, removed from uppermost of buried midden lenses. Coll Oct 1986 by J Erlandson. *Comment:* thin (5cm) midden stratum consists primarily of whole valves of fragile mussels, *Mytilus* and *Septifer,* including articulated specimens indicating unusual degree of preservation for Santa Barbara coast. Date suggests that landform stabilized shortly after 1300 yr BP, supported by overlying soil (A-1) between 80cm and 120cm thick.

BAI Beta-20407. Stratum A-2, −160cm **2340 ± 80**

Valve of *Hinnites multirugosus* (Giant Rock Scallop), 96g, recovered from thin midden lens underlying A-1 soil series. Coll Dec 1986 by J Erlandson. *Comment:* date is consistent with stratigraphic context, since 25cm thick soil (A-1[6]) formed between A-1 and A-2 soils, which are also separated by erosional unconformity. Stratum A-2 contained hearth feature and small discrete midden dumps, samples of which contained over 95% *Mytilus* by weight.

BAI Beta-20408. Stratum A-7, −300cm **2550 ± 80**

Mytilus californianus fragments, 26g, from test unit 3, Feature 2, concentrated shell dump (much of it burned). Coll Dec 1986 by J Erlandson and L Santoro. *Comment:* date suggests that A-2 through A-9 soils were all deposited relatively rapidly, probably between 2300 and 3000 yr BP.

BAI Beta-20409. −350cm **560 ± 100**

Wood removed from outer layers of *in situ* tree stump (tentatively identified as oak) exposed below water table at base of numerous interdigitated beach, estuarine, and fluvial strata on W side of canyon floor. Coll Oct 1986 by J Erlandson and D James. *Comment:* date is consistent with archaeologic strata to E; fluvial, marsh, and beach sediments were deposited following erosional episode which truncated a portion of A-1 soil series.

General Comment: CA-SBA-1881 appears to consist of a series of temporary campsites occupied during dry seasons (summer or fall) when Agua Caliente Creek was at low water stage. Periodic flooding buried archaeologic features and refuse with unusual degree of preservation. While few artifacts were recovered from site, faunal assemblage suggests that shellfish gathering, deer hunting, and fishing, were primary subsistence pursuits. As with ^{14}C series from CA-SBA-1808, coastline around site appears to have been dominated by rocky intertidal habitats.

BAI Beta-10226. CA-SBA-1494A, −80cm **1340 ± 70**

Fragment of *Hinnites multirugosus*, 28g, from ca 75cm below surface in sea cliff exposure of large site at mouth of Bulito Canyon on Hollister Ranch (34° 27′ 30″ N, 120° 20′ 00″ W). Site is on broad flood plain of perennial Bulito Creek at elev 3 to 4m asl. Coll 1984 by J Erlandson and F Duncan, UCSB. *Comment:* CA-SBA-1494 is reportedly site of historic Chumash village of *Texax*. Date significantly antedates beginning of Late period, suggesting that historic village deposits may have eroded into sea. Sample is also min for uppermost of several soils exposed in sea cliff, suggesting that alluviation has been active for much of Holocene.

BAI Beta-10227. CA-SBA-1658, −40cm **1080 ± 70**

Fragment of *Haliotis rufescens* (red abalone), 62g, from 40cm below surface in sea cliff profile. Site is on stream terrace W of intermittent Cuarta Creek, elev 10 to 12m, Hollister Ranch (34° 28′ 00″ N, 120° 17′ 30″ W). Coll 1984 by J Erlandson and F Duncan, UCSB. *Comment:* date suggests site occupation may span transition between King's (1981) Middle and Late periods. Available data suggest that sea mammal hunting, fishing, and land mammal hunting, were primary subsistence pursuits of site occupants, with shellfish providing only supplemental protein.

CA-SBA-1491, *Estait* Late Holocene series

Marine shells from historic Chumash village of *Estait* (CA-SBA-1491), on flood plain at mouth of Canada de la Santa Anita (34° 28′ 00″ N, 120° 18′ 30″ W) on Hollister Ranch. *Estait* reportedly contained 130 inhabitants in AD 1769 and appears to have been abandoned by AD 1810. Samples derive from two discrete loci (B and C) at site, on broad stream terrace on either side of perennial Santa Anita Creek at ca 10m elev. Pacific Ocean lies 300m to S.

BAI Beta-10225. Locus C, surface **220 ± 70**

Fragment of *Haliotis rufescens,* 52g, from midden deposit located on the E side of Santa Anita Creek. Coll autumn 1984 by J Erlandson and F Duncan. *Comment:* date correlates well with artifact assemblage that includes both late protohistoric shell beads, historic glass beads, and late arrowpoint styles.

BAI Beta-12947. Unit 7, 20–40cm **760 ± 80**

Fragment of *Haliotis rufescens,* 41.6g, recovered from upper portion of midden deposit at Locus C. Coll May 1985 by R Carrico and T Cooley, WESTEC Services. *Comment:* date correlates with early stages of Late period as defined by King (1981) and may derive from early portion of site occupation.

BAI Beta-12948. Unit 7, 100–120cm **470 ± 60**

Multiple shell fragments, 33g, of mixed spp from lower levels of midden deposit in Locus C. Coll May 1985 by T Cooley and R Carrico. *Comment:* date represents average for shell fragments analyzed. Stratigraphic reversal between this and Beta-12947 may result from stratigraphic mixing by burrowing rodents (Erlandson, 1984; Erlandson & Rockwell, 1987).

BAI Beta-15046. Unit 6, 0–20cm **300 ± 80**

Protothaca staminea (Littleneck clam) fragments, 28g, from upper level of midden at Locus C. *Comment:* since *Estait* was abandoned ca AD 1800, this date and Beta-10225 suggest that correction for reservoir effect cannot exceed offsetting isotopic fractionation correction (which averages 430 yr on Santa Barbara coast) by >100–150 yr.

BAI Beta-15047. Unit 6, 20–40cm **470 ± 80**

Protothaca staminea fragments, 28g, from Locus C, coll June 1985 by T Cooley. *Comment:* provides average age of shell fragments subm for analysis.

BAI Beta-15048. Unit 6, 40–60cm **640 ± 60**

Protothaca staminea fragments, 20g, recovered from lower portion of midden in Locus C. Coll June 1985 by T Cooley. *Comment:* three dates from Unit 6 are stratigraphically consistent.

BAI Beta-15049. Unit 7, 0–20cm **430 ± 80**

Protothaca staminea fragments, 28g, from Locus C. Coll May 1985 by T Cooley and R Carrico. *Comment:* sample subm to check validity of reversed dates (Beta-12947 and -12948) from Unit 7. This sample suggests that Beta-12947 may have been redeposited by either natural or cultural processes (Erlandson & Rockwell, 1987).

BAI Beta-15050. Unit 7, 20–40cm **Modern**

Protothaca staminea fragments, 28g. Coll May 1985 by T Cooley and R Carrico. *Comment:* ^{14}C activity indistinguishable from modern standard.

BAI Beta-12946. Locus B, 0–90cm **500 ± 60**

Haliotis rufescens fragment, 46g, from Shovel Test Pit 503 in midden area of Locus B, W side of Santa Anita Creek. Coll May 1985 by T Cooley. *Comment:* late prehistoric date suggests Locus B was occupied contemporaneously with Locus C.

BAI Beta-17210. Unit 20, 20–40cm **670 ± 70**

Fragment of *Tivela stultorum,* 74g, from upper portion of shell midden at Locus B. Coll 1986 by T Cooley and L Santoro. *Comment:* sample pulled from dense midden deposit rich in discarded artifacts, fire-cracked rock, marine shell and animal bone, especially fish remains.

BAI Beta-17211. Unit 20, 40–60cm **400 ± 80**

Fragment of *Haliotis rufescens,* 54g, from center of dense midden 1m deep. Coll 1986 by T Cooley and L Santoro. *Comment:* date is slightly younger than previous sample taken from overlying level.

BAI Beta-17212. Unit 20, 60–80cm **260 ± 80**

Fragment of *Haliotis rufescens,* 31g. Coll 1986 by T Cooley and L Santoro. *Comment:* since Unit 20 appeared to cut through intact cultural feature, reversed ^{14}C dates from this unit may be attributed to cultural disturbance assoc with site occupation.

BAI Beta-17213. Unit 20, 80–100cm **310 ± 90**

Haliotis rufescens fragment, 16g, from near base of dense midden deposit at Locus B. Coll 1986 by T Cooley and L Santoro. *Comment:* with exception of Beta-17210, all dates from Unit 20 could be attributed to late

prehistoric or early historic period, after appropriate corrections are considered.

General Comment: consistent with ethnohistoric accounts of Chumash Indians, archaeologic materials recovered indicate technology and economy were heavily maritime in nature, with strong emphasis on fishing. However, land mammal, sea mammal, and shellfish remains are abundant, suggesting broadening of resource base. For the first time, small arrow points are present in the study area, indicating the widespread adoption of the bow and arrow by 400 to 600 cal BP.

Mollusk spp recovered suggest that a mosaic of sandy bay and rocky shore habitats provided most shellfish, and that estuarine contributions were negligible. Coastal habitats around site appear to have attained an essentially modern configuration by 500 BP.

CONCLUDING REMARKS

For at least 8600 years, marine resources have played a major role in the economy of hunter-gatherers living on the Santa Barbara coast. During this period, however, the relative contribution of various marine and terrestrial resources to the prehistoric diet has varied in response to interrelated changes in the internal (cultural) and external (environmental) stimuli that influence human adaptation (Glassow, Wilcoxon & Erlandson, 1987). The archaeologic evidence available from the study area suggests that changes in coastal paleogeography have played an important role in determining the structure of human settlement and subsistence during the Holocene, perhaps even more important than climatic variations on a global scale (*ie,* the Altithermal).

At the Early Holocene sites investigated, the recovered tool and faunal assemblages suggest that shellfish provided the majority of dietary protein, while plant foods satisfied most of the energy (calorie) requirements. Early Holocene shellfish collectors required little in the way of specialized technology, with the exception of manos and metates for grinding vegetable foods. In fact, although several hundred artifacts associated with plant processing were recovered at CA-SBA-1807, only one crude projectile point was found. The early Holocene adaptation along the Santa Barbara coast appears to have been possible because of the presence of abundant littoral and plant resources and low human population densities.

Throughout the Holocene, sea-level rise and (later) sea-cliff retreat (up to 15cm per yr) must have gradually reduced terrestrial productivity by restricting the available land area south of the Santa Ynez Mts (Erlandson, 1985). After sea level stabilized (ca 6000 BP), the productivity of littoral habitats must also have declined as estuaries east of Point Conception filled with sediment. As terrestrial and littoral productivity appear to have gradually declined, relative nearshore marine productivity may have increased after 6000 BP as a stable sea level cut a progressively wider shallow offshore platform (Yesner, 1980).

These environmental changes, accompanied by population rise, appear to be the primary stimuli behind a technologic diversification reflecting adaptive broadening of the subsistence base. In particular, hunting

technology was increasingly diverse and plentiful during the Middle Holocene, with a variety of large projectile point types (spear and/or atlatl?) being used. Sometime after 1000 BP, small arrow points became abundant, indicating the widespread adoption of the bow and arrow. Fishing and fishing technology also became increasingly abundant and diverse through time, culminating in the fully maritime adaptation of the ethnohistoric Chumash Indians.

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